Rehabilitating wetlands in the Gippsland Lakes Ramsar site: the benefits and limitations of community involvement

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Abstract
The Gippsland Lakes are one of Australia's most important and highly used estuarine complexes. Development pressures have caused the degradation of many of the Ramsar-listed, brackish-water wetlands that fringe the Gippsland Lakes. Two developments stand out as critically important: i) the creation of a permanent opening to Bass Strait in 1889 at Lakes Entrance; and ii) the increasing extraction of freshwater from the Latrobe, Macalister and Thomson Rivers for use by irrigators and industry and as a supply of potable water for Melbourne. One of the largest of the Ramsar-listed wetlands in the Gippsland Lakes—Dowd Morass—was the subject of an intensive rehabilitation project from 2003 to 2007. The project benefited greatly from community involvement, particularly with revegetation efforts and in the re-establishment of more natural wetting and drying regimes. The benefits and limitations of community involvement are discussed, with a focus on community perceptions of wetland values and degradation; the impacts of carp and of exotic weeds are two cases where there was little congruence between the perceptions of community groups and those of professional aquatic ecologists. The wider use of conceptual models is one way to improve understanding and enhance collaboration across different groups in large, multi-disciplinary projects that seek to rehabilitate high-value coastal wetlands. (*The Victorian Naturalist* 131 (4) 2014, 106–114)

Keywords: *Melaleuca*, *Phragmites*, restoration, salinity, water regime

The Gippsland Lakes: their economic, social and environmental values

The Gippsland Lakes, currently Australia's largest navigable inland waterway, are located on the south-eastern coast of Victoria in southern Australia. They consist of three large coastal lagoons (Lake Wellington – 148 km^2; Lake Victoria – 75 km^2; and Lake King – 98 km^2), fed by seven rivers, plus an extensive mosaic of fringing wetlands that line the edges of the lagoons and the lower reaches of the inflowing rivers. The lagoons have a shoreline of 320 km and the rivers drain a catchment of 20 600 km^2, just over one-tenth of the State of Victoria (Bird 1978). The entire complex of lagoons, wetlands and the lower reaches of the main rivers is listed under the Ramsar Convention as the Gippsland Lakes Ramsar site, which covers an area of 60 015 ha.

The Lakes provide a wide range of ecosystem services and are a vital component of the Victorian economy. They support Victoria's largest commercial fishing fleet and the single largest recreational fishery in the State for the iconic Black Bream *Acanthopagrus butcheri* Munro 1949 (Department of Primary Industries 2006). The social value of the Lakes for recreation, visual amenity and in providing habitat for wildlife and biodiversity is reflected in the economic value of the tourism industries they support. It has been estimated that in 2006, the Lakes attracted over 4 500 000 visitor days, including nearly 2 400 000 spent in overnight visits and nearly 1 500 000 in local day visits (URS 2008). URS (2008) calculated the non-market value of four of the large wetlands in the Gippsland Lakes Ramsar site (Clydebank Morass, Dowd Morass, Heart Morass and Sale Common) at $1.15 million (in 2006 dollars) for their biodiversity value alone.

Nevertheless, there are significant threats to these very high environmental, social, and economic values. The decline in Black Bream catches over the past 40 years has been stark (Department of Environment and Primary Industries 2010), critical water-quality objectives, for example for Dissolved Phosphorus and for Dissolved Oxygen, regularly exceed the objectives set out in the State Environment Protection Policy (Waters of Victoria), and recurrent algal blooms are a worrying phenomenon (Environmental Protection Authority [EPA] Victoria 2013). Threats to water quality come from a number of sources, including high nutrient and sediment loads from the inflowing rivers, bank erosion, and the decline of fringing vegetation. One process leading to these changes in environmental condition has been progressive salinisation of the lakes and their fringing wetlands, which in turn is due to two factors. The first is the construction of a permanent opening to Bass Strait in 1889 at Lakes Entrance, which converted the Lakes from an intermittently open and closed lagoonal system to one with a permanent (and dredged) opening to the sea (Bird 1966). The second is the marked reduction in flow in the rivers that discharge into the western parts of the Gippsland Lakes (Moroka 2010). Over one-third of all flows is currently extracted from the Latrobe River (and its tributaries, the Thomson and Macalister Rivers), for agricultural, industrial, and potable use. As a result of both processes, many of the wetlands that fringe the lower parts of these rivers have become increasingly saline, with marked changes to plant species composition and to the ecological condition of vegetation communities (Boon *et al.* 2008; Raulings *et al.* 2010, 2011; Robinson *et al.* 2012; Salter *et al.* 2007, 2008, 2010a, b; Sinclair and Boon 2012). That such changes would occur as a consequence of increasing salinisation were predicted nearly half-a-century ago by Bird (1966).

From 2003 to 2007 I led a large, multi-disciplinary research and development (R&D) project to rehabilitate Dowd Morass, one of the largest of the Ramsar-listed, brackish-water wetlands that fringe the western parts of the Gippsland Lakes. The selection of Dowd Morass was predicated on three requirements: i) the wetland had to be of demonstrable high value (e.g. Ramsar-listed); ii) it had to be amenable to a landscape-scale manipulation of water regimes; and iii) the undertaking had to be explicitly embedded within a strong program of regional natural-resource management, including the involvement of local management agencies and communities in the project and in the implementation of its major findings.

Dowd Morass was ideal because it had been subject to very tight control of its wetting and drying cycles over the past 30 years: since the mid-1970s, it had been kept almost permanently inundated to provide for waterfowl hunting, to allow for breeding of colonial-breeding waterbirds, and to prevent intrusions of saline water from the adjacent Lake Wellington. Moreover, a series of levees had been constructed inside the morass in the mid-1970s when it was in private ownership; these allowed us to implement a landscape-scale manipulation of water regime to determine whether the ecological condition of the wetland could be improved by re-introducing more natural patterns of wetting and drying. Finally, the local community, both at the level of government agencies, such as Parks Victoria and the East and West Catchment Management Authorities, and in terms of local organisations such as Field and Game Australia and the Field Naturalists Club of Victoria, was deeply involved in the project. This paper analyses some of the complex interactions that occurred among community groups, government agencies, and scientifically trained ecologists, and draws out the strengths and weaknesses of community involvement in such wetland-rehabilitation projects.

Dowd Morass

A brief history of Dowd Morass and alterations to its hydrology

Dowd Morass, at 1500 ha, is one of the largest wetlands within the Gippsland Lakes Ramsar site and is located on the southern bank of the Latrobe River, near where the river debouches into Lake Wellington, at the western end of the Gippsland Lakes. Scottish Highlanders were among the first Europeans to explore and settle Gippsland (Watson 1984) and were probably responsible for naming many of the wetlands as 'morasses'.

Land around Dowd Morass was being privately developed by 1888, and by 1942 almost all the wetland was in private ownership (State Rivers and Water Supply Commission 1972). A series of levee banks approximately 0.9–1.9 m Australian Height Datum (AHD) was constructed within the wetland in 1973 'with a view to drainage and development for agricultural purposes' (State Rivers and Water Supply Commission 1972: 1), as well as to prevent overbank flows from the Latrobe River and to prevent brackish water from Lake Wellington entering the western side of the morass (Keith Heywood, local landowner, pers. comm.). The largest of the levees—Heywood's embankment

—runs north–south and almost completely separates the eastern from the western sections of the wetland. Two artificial drains were constructed in the early 1970s to establish a hydraulic connection between Dowd Morass and the Latrobe River.

In 1975 the State Government purchased Dowd Morass as a State Game Reserve, and breaches were created in the levees to improve internal water circulation. The morass was flooded in 1975 from the Latrobe River, through the larger of the two artificial drains dug earlier in the decade. This flooding was intended to reduce saline intrusions from Lake Wellington as well as to provide better opportunities for waterfowl hunting (A Schulz, Parks Victoria, pers. comm.). The drains at that time did not have structures to allow control of the direction or volume of water flow from the river.

Except for three short periods, the wetland has been kept fully flooded almost continuously since this flooding in 1975. The first was in 1983, during a nationwide drought, when the morass would have dried completely but for the digging of a channel by persons unknown and the flooding of the wetland with moderately saline water from the Latrobe River. The second was during an experimental draw-down of water levels in 1997/98 by Parks Victoria, the state government agency that manages the wetland. The third, during the summers of 2003/04 and 2004/05, was the intervention we implemented as part of the trial to reintroduce more natural wetting and drying regimes into the wetland (Raulings *et al.* 2010, 2011).

In 1987 the existing drains were repaired by Parks Victoria with help from the regional Field and Game Australia hunting club, and the structures were further improved in 2000 when stainless steel flaps were fitted to the culverts to allow water movement into and out of the wetland from the river to be controlled. From 1987 to 1997 the morass was managed primarily to maintain stable water levels for colonial breeding waterbirds, by not drawing down water levels from September to December each year. The resultant water regime was not inconsistent with earlier intentions to maximise opportunities for duck hunting and to prevent intrusions of saline water from Lake Wellington, but is markedly different from what was probably the natural hydrology of the wetland. It is thought that prior to European settlement Dowd Morass would have filled with sediment- and nutrient-laden fresh water from the adjacent Latrobe River during winter-spring floods, and with less turbid water of variable salinity from Lake Wellington when wind conditions were suitable and when the water level of Lake Wellington exceeded the shoreline level of Dowd Morass (Sinclair Knight Merz 2003). Surface-water levels in the wetland would therefore have fluctuated in response to complex seasonal patterns of precipitation, runoff and evaporation, as well as with the state of the intermittent opening to the ocean, just north of today's township of Lakes Entrance. It has been proposed too that prior to European settlement Dowd Morass and other wetlands in the Lake Wellington wetlands complex would have dried out about once every five years (Parks Victoria 1997). To my knowledge, no palaeobotanical studies have been undertaken to lend support to this notion (the palaeoecological work of Saunders *et al.* (2008) was concerned with Lake King).

Impact of altered hydrology and salinity on wetland vegetation

The dominant vegetation in Dowd Morass is a woodland of Swamp Paperbark, *Melaleuca ericifolia* Sm, which covers about 500 ha (Boon *et al.* 2008). Swards of Common Reed *Phragmites australis* (Cav.) Trin. ex Streud, cover about 350 ha, and the remainder of the wetland is open water or bare mudflat. *Melaleuca ericifolia*, a clonal wetland shrub or tree, is the dominant woody plant in many coastal and near-coastal wetlands across southern Australia, where it forms a vegetation community known as Swamp Scrub which is critically important as nesting and roosting habitat for colonially breeding waterbirds (Bird 1962; Corrick and Norman 1980; Cowling and Lowe 1981).

A large rookery of colonially breeding waterbirds, consisting mostly of Australian Ibis *Threskiornis molucca* Cuvier 1829, Straw-necked Ibis *Threskiornis spinicollis* Jameson 1835 and Royal Spoonbills *Platalea regia* Gould 1838, is located in the south-west corner of the morass. Ibis have bred in Dowd Morass since at least 1961, with notable breeding periods occurring in 1965 to 1970 inclusive, 1974, and

1978 (Cowling and Lowe, 1981). The birds roost and breed almost entirely in the Swamp Paperbark woodlands.

In the mid-1990s, Parks Victoria staff were concerned that the near-permanent inundation of Dowd Morass since 1975 was having adverse impacts on the condition of *M. ericifolia* and thus on the breeding success of ibis and spoonbills. It is likely that the altered water regime would have contributed to declining condition of *M. ericifolia* woodlands, as *M. ericifolia* seed cannot germinate under flooded conditions (Ladiges *et al.* 1981; Robinson *et al.* 2006); nor can young seedlings establish (Salter *et al.* 2007, 2010b). The growth and survival of established plants is also compromised by deep, permanent water (Morris *et al.* 2008; Salter *et al.* 2010a). Concerns that the existing water regime was responsible for widespread degradation of *M. ericifolia* in the critical ibis rookery area prompted Parks Victoria to partly drain the morass in March 1997. In the winter of 1998, however, the eastern rivers that flow into the Gippsland Lakes were in flood and their large discharge caused saline water to back up in Lake Wellington, as the entrance to Bass Strait at Lakes Entrance was too small to let flood water pass from the swollen Lakes Victoria and King out to the sea. Saline water was thus pushed into the western parts of the lakes and eventually up into Dowd Morass via the shallow opening between it and Lake Wellington ('The Dardanelles') and via over-bank flow along the lower Latrobe River once it too had backed up from Lake Wellington (Sinclair Knight Merz 2003). This saline water then flowed into the partly drained Dowd Morass, exacerbating the prior hydrological problem with a possibly even more severe salinity problem.

Water levels in the morass have been kept high since the temporary draw-down of 1997/98, in order to prevent a repeat occurrence of saline intrusions, to provide stable water for waterfowl hunting, and to provide habitat for the colonial breeding waterbirds. But the problem remains, that the *M. ericifolia* woodlands are likely to degrade further because of the inappropriate hydrological regime, probably exacerbated by chronic and/or acute secondary salinisation processes. Regional natural-resource managers also face the complication that Dowd Morass, like many other wetlands along the Gippsland coast, overlays potential and/or active acid sulfate soils created as a result of the wetlands' coastal position and recent (10 000 years BP) history of post-Holocene sea level changes. The presence of these soils makes any attempt to reintroduce more natural wetting and drying regimes even more fraught.

Community involvement in rehabilitating Dowd Morass

Community attitudes to wetlands of the Gippsland Lakes

Immediately after the R&D project started in early 2003, a series of workshops were conducted with two of the most relevant community groups in the region: Sale and District Field Naturalists, and Field and Game Australia (Sale and District branch). The purpose of these workshops was three-fold: i) to inform the regional community about the project; ii) to determine whether they saw the need for, and supported, the type of research being undertaken in the Gippsland Lakes; and iii) to determine whether they would be interested in participating directly in it. The two groups broadly covered the interests of amateur biologists and conservationists, and hunting and fishing interests respectively, but the division does not necessarily mean that their interests were always incompatible.

At the conclusion of the introductory workshops, a short questionnaire of 12 Likert-type questions was distributed. The Likert scale is a psychometric measure commonly used in questionnaires and surveys, where participants are invited to rank their agreement or disagreement to a series of statements or questions (Likert 1932). Typically a five-level response is invited, ranging from strong agreement (score of 5) to strong disagreement (score of 1), via an intermediate of 'neither agree nor disagree' with a score of 3. The return rate for each group was 85% (18 from 21 at the Field Naturalists' meetings; 29 from 34 at Field and Game meetings). The results are shown in Fig. 1, 2 and 3.

Both community groups were highly aware of the wetlands fringing the Gippsland Lakes, with Likert scores exceeding 4 out of the highest possible score of 5 (i.e. a score of 1 = not aware and a score of 5 = highly aware). Almost all respondents thought the wetlands were integral to the larger Gippsland Lakes (Likert score >4.5 out of 5). This is an important finding because until recently there was a tendency among some natural-resource managers, and even among some scientists, to consider the lagoonal components of the Gippsland Lakes separately from the fringing wetlands.

One question addressed the topic of why local residents valued the wetlands of the Gippsland Lakes. As expected a wide range of reasons was expressed, but among the most common reasons were aesthetics, recreation, and environmental values (Fig. 1). The main difference in responses between the two community groups was that 'sport' was rated highly by Field and Game members but very lowly by Field Naturalist members. Field and Game members also ranked the provision of 'ecosystem services' more highly than did Field Naturalists.

Subsequent questions addressed wetland condition (Fig. 2). Field and Game members thought the wetlands were in poorer condition than did the Field Naturalists, although both groups tended to the view that the wetlands were in only 'fair' condition. Field and Game members perceived a decrease in wetland condition over time, whereas Field Naturalists returned a Likert score of 2.5 out of 5, indicating that they perceived no great change in condition (data not shown). A wide range of factors was proposed as causing wetland degradation: the presence of Carp *Cyprinus carpio* L., an introduced fish species, was an almost ubiquitous explanation, followed by an inappropriate water regime, salinity impacts, and the generic term 'plant loss'. Weed invasions were problematic for Field Naturalists but less so for Field and Game members. 'Excess bird numbers' was identified by 21% of Field and Game members as contributing to wetland degradation. It is likely, however, that ibis rather than huntable species such as waterfowl, were the birds identified as being 'too abundant'. What might seem to be an esoteric cause of environmental degradation to many people not familiar with wetlands – acid sulfate soils – was identified by 17% and 24% of Field and Game and of Field Naturalists members, respectively. We deliberately left the meaning of the terms 'condition' and 'degradation' open, so that respondents could reply in terms of what they perceived as a change in wetland condition and the factors responsible for any degradation.

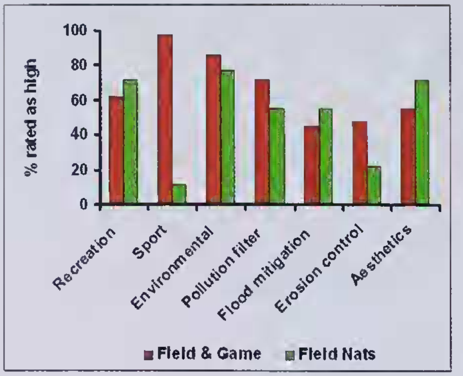

Fig. 1. Comparison of responses from two contrasting community groups (Field and Game Victoria Sale and District branch, and Field Naturalists Club of Victoria) on the value of Dowd Morass. The y axis shows the percentage of respondents who placed a rating of 'high' for the various values indicated along the x axis.

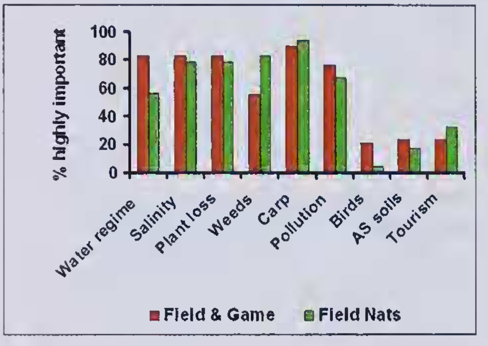

Fig. 2. Comparison of responses from two contrasting community groups (Field and Game Victoria Sale and District branch and Field Naturalists Club of Victoria) on the factors believed to cause degradation of Dowd Morass. The y axis shows the percentage of respondents who placed a rating of 'highly important' for the various threats indicated along the x axis. AS soils = acid sulfate soils.

The penultimate question sought feedback on the project's relevance to the better management of wetlands in the Gippsland Lakes Ramsar site, and the final question sought to determine whether members were willing to be involved in various aspects of the project. The two groups returned very high Likert scores (4.6 and 4.7 out of 5) for the 'relevance' question, which indicated they thought the R&D project was strongly relevant to the better understanding and management of the Gippsland Lakes and its fringing wetlands. As discussed below, this was an important conclusion because it allows us to further justify the project to its financial backers in Commonwealth and State Governments. Over three-quarters of respondents (76% for Field and Game; 83% for Field Naturalists) wanted to be involved in some aspect of the project. When asked what activities were of most interest, revegetation and bird counts, followed by water quality monitoring and frog counts, were common responses (Fig. 3). We took advantage of these positive responses in later aspects of the project, as discussed next.

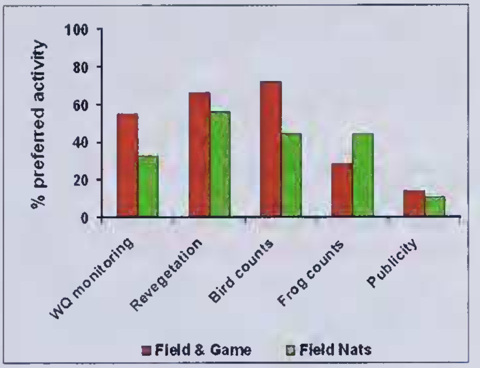

Fig. 3. Comparison of responses from two contrasting community groups (Field and Game Victoria Sale and District branch and Field Naturalists Club of Victoria) on the activities they would prefer to be involved in as part of the R&D project on Dowd Morass. The y axis shows the percentage of respondents who placed a rating of 'would like to be involved' for the various activities indicated along the x axis. WQ monitoring = Water quality monitoring

Examples of on-ground community involvement

Members of Field and Game and the Field Naturalists, as well as other community groups such as local schools, were heavily involved with active revegetation of degraded parts of the wetland with *M. ericifolia* seedlings. The results of these revegetation trials have been reported in Raulings *et al.* (2007). Over 2000 root-stock seedlings were planted during the conduct of the revegetation experiments, and it would have been impossible for the research team to plant this many seedlings in the complex array of experimental areas without the help of the many volunteers from local community groups.

Volunteers from community groups also were instrumental in the two experimental drawdowns of water levels attempted over 2003 to 2005. With the assistance of Parks Victoria staff and volunteers from Field and Game, repairs were made to gaps that had developed over the past three decades in the internal levees subdividing Dowd Morass. Repairs to Heywood's embankment in particular were required so that the east and west sides of the wetland could be physically isolated and their water levels manipulated independently in a planned Before-After-Control-Impact (BACI) experimental design, even if a different technique—gradient analysis—was used for the final statistical analysis: see Raulings *et al.* (2010, 2011) for details.

Community-group volunteers not only repaired the levees, but were active in monitoring water quality in the wetland (through the regional Waterwatch initiative, membership of which was common within the Field Naturalist group) whilst water levels were being manipulated, and in providing surveillance against vandalism. Perhaps most importantly, volunteers from Field and Game maintained the two pumps that maintained contrasting water levels in the two parts of the wetland: large, diesel-fuelled agricultural pumps were used to pump water from various parts of Dowd Morass and they had to be maintained regularly (e.g. fuel supply, periodic changing of filters etc). The costs of maintaining the engines and centrifugal pumps from our base in Melbourne were prohibitive, but diesel engineers who happened to be members of Field and Game donated their services to maintain the pumps and, as far as possible, ensure they were kept under periodic surveillance to guard against vandalism. (Vandalism was initially a problem, as outlined in Raulings *et al.* 2011).

The final benefit of collaboration with community groups was that it further demonstrated to the government funding agencies (which provided most of the financial support) that the project had significant local backing. Such a demonstration was particularly important for the gaining of Commonwealth support for the project. Salt *et al.* (2008) also found that strong public support was needed to secure the legislative funding necessary for successful rehabilitation of the Everglades wetlands in Florida (USA).

Comparisons of community and scientific understanding

One area of community involvement and the utilisation of local knowledge that has become increasingly valued in the rehabilitation of degraded landscapes is the construction of historical narratives, which provide a long-term perspective of environmental change in a given region (Robertson *et al.* 2000; Bart 2006). These historical perspectives are especially powerful if they include repeat photographs of chosen sites to complement verbal descriptions (Pickard 2002). McClanachan (2008) provides a striking example of how historical photographs can be used to track environmental degradation in aquatic systems. Some information of this nature is available for the Gippsland Lakes (e.g. Ellis and Lee 2002), but it is not as detailed as the oral and photographic history that has been documented for the Tuggerah Lakes, a broadly comparable coastal lagoonal system in central New South Wales, by Scott (1998). Given the lack of a well-described community narrative, we sought to draw out what the community perceived as the factors most responsible for wetland degradation and how those views compared with the understandings of the professional aquatic ecologists involved in the R&D project.

During the project we became aware of several cases where the oral tradition (expressed as community beliefs summarised in Figs. 1, 2 and 3) was in close agreement with scientific understanding of wetlands and their ecology. In other cases there were clear mismatches. One example is the perception by many community members that carp were largely responsible for the ecological degradation of Dowd Morass (Fig. 2). This belief does not match with the scientists' understanding of the factors primarily responsible for the degradation of Dowd Morass: firstly an inappropriate water regime, exacerbated by secondary salinisation; followed by nutrient enrichment; and finally, the presence of acid sulfate soils. The identification of carp by community groups as the main culprit in the degradation of wetlands is not surprising, given that carp are highly visible exotic fauna that have been the topic of several regional workshops and that they are episodically abundant throughout fresh and brackish water parts of the Gippsland Lakes. But many community perceptions of carp-mediated impacts are simply wrong: Koehn *et al.* (2000), for example, identified 12 common perceptions about carp that were not supported by scientific facts, including that carp can remain alive in mud for long periods and that they undermine riparian trees and river banks. Many of these putative abilities were expressed during the workshops of 2003.

A second example of a mismatch between community (and even management) beliefs and scientific understanding is weed infestations, which were seen as especially problematic by Field Naturalists but less so by Field and Game members (Fig. 2). Indeed, the draft management plan for the Lake Wellington wetlands (Parks Victoria 1997) identified Brazilian Milfoil *Myriophyllum aquaticum* Vell.Verdc.; syn. *Myriophyllum brasiliense* Cambress. as the critical aquatic weed species in wetlands of the western parts of the Gippsland Lakes. An analysis of the salinity and flooding tolerance of *M. aquaticum* undertaken as part of our rehabilitation assessment concluded that the species was too salt-sensitive to pose a major threat to brackish-water wetlands in the Gippsland Lakes, especially given salinity regimes over the past decade (Toomey and Boon 2007).

Conversely, however, the identification of acid sulfate soils as a major problem by ~20% of respondents agreed very well with scientific understanding of the critical role soil acidification can play in degrading *Melaleuca*-dominated coastal wetlands (and their adjacent receiving waters) along the eastern seaboard of Australia (e.g. Johnston *et al.* 2003; Eyre *et al.* 2006).

Conceptual models as a communication tool

One way to achieve congruence across the different groups involved in the management and rehabilitation of Ramsar-listed wetlands is to create a suite of conceptual models that show how wetlands respond to changing environmental conditions, such as altered water and salinity regimes. Conceptual models can be developed to illustrate a range of ecological structures, processes, responses and interactions, and are highly effective in capturing the current scientific knowledge of an ecosystem and showing likely ecological responses to natural and anthropogenic stresses (e.g. Gentile *et al.* 2001). They are an essential – albeit usually neglected – component of the adaptive management framework (Walters 1986), and are especially valuable because they should prompt continued re-evaluation of what is known about a given ecosystem, as well as making explicit the ecological principles that underlie the rehabilitation of degraded areas (Weiher 2007).

The creation of a conceptual model of Gippsland Lakes' wetlands would serve a valuable role in promoting collaboration across the different parties in large, multi-disciplinary R&D projects: such a model should integrate knowledge from the oral tradition, scientific understanding, management expectations, and community perceptions about wetland uses, rehabilitation and water use. The irony here is that in his pioneering book chapter of 1966, Eric Bird included a simple and elegant predictive conceptual model of how vegetation in the Gippsland Lakes would respond to progressive salinisation (Bird 1966). Perhaps it just shows that important advances in the resolution of the environmental issues we face today were often made many years ago, by an older generation of scientists. It also indicates that it pays not to neglect this older literature, nor the perspectives of the 'elders' (scientific and community) in our society, many of whom have valuable scientific and natural history perspectives on matters such as the health of the Gippsland Lakes and its fringing wetlands, and the best ways degraded sites can be rehabilitated.

References

Bart D (2006) Integrating local ecological knowledge and manipulative experiments to find the causes of environmental change. *Frontiers in Ecology and the Environment* **4**, 541–546.

Bird ECF (1962) The swamp paper-bark. *The Victorian Naturalist* **79**, 72–81.

Bird ECF (1966) The impact of man on the Gippsland Lakes, Australia. In *Geography as Human Ecology*, pp 55–73. Ed SR Eyre and GRJ Jones. (Edward Arnold: London)

Bird ECF (1978) The Geomorphology of the Gippsland Lakes Region. Ministry for Conservation Publication 186, Melbourne.

Boon PI, Raulings E, Roache M and Morris K (2008) Vegetation changes over a four-decade period in Dowd Morass, a brackish-water wetland of the Gippsland Lakes, south-eastern Australia. *Proceedings of the Royal Society of Victoria* **120**, 403–418.

Corrick AH and Norman FI (1980) Wetlands and waterbirds of the Snowy River and Gippsland Lakes catchment. *Proceedings of the Royal Society of Victoria* **91**, 1–15.

Cowling SJ and Lowe KW (1981) Studies of ibises in Victoria, I: records of breeding since 1955. *Emu* **81**, 33–39.

Department of Environment and Primary Industries (2010) Fisheries status report 2010. 8. Black Bream fishery. http://www.dpi.vic.gov.au/fisheries/about-fisheries/publications-and-resources/fisheries-reports/fisheries-report-series/fisheries-status-report-2010/black-bream-fishery Viewed 9/12/2013.

Department of Primary Industries (2006) Fisheries Victoria commercial fish production. Information Bulletin 2005. Department of Primary Industries, Queenscliff.

Ellis J and Lee T (2002) *Casting the Net: Early Fishing Families of the Gippsland Lakes*. (Lakes Entrance Family History Resource Centre: Lakes Entrance)

Environmental Protection Authority Victoria (2013) Gippsland Lakes Condition Report 1990–2011. EPA Victoria Scientific Report No. 1530, Carlton.

Eyre BD, Kerr G and Sullivan LA (2006) Deoxygenation potential of the Richmond River estuary floodplain, northern NSW, Australia. *River Research and Applications* **22**, 981–992.

Gentile JH, Harwell MA, Cropper W, Harwell CC, DeAngelis D, Davis S, Ogden JC and Lirman D (2001) Ecological conceptual models: a framework and case study on ecosystem management for South Florida sustainability. *Science of the Total Environment*, **274**, 231–253.

Johnston SG, Slavich PG and Hirst P (2003) Alteration of groundwater and sediment geochemistry in a sulfidic backswamp due to *Melaleuca quinquenervia* encroachment. *Australian Journal of Soil Research* **41**, 1343–1367.

Koehn J, Brumley A and Gehrke P (2000) *Managing the Impacts of Carp*. (Bureau of Rural Sciences: Canberra)

Ladiges PY, Foord PC and Willis RJ (1981) Salinity and waterlogging tolerance of some populations of *Melaleuca ericifolia* Smith. *Australian Journal of Ecology* **6**, 203-215.

Likert R (1932) A technique for the measurement of attitudes. *Archives of Psychology* **140**, 1–55.

McClanachan L (2008) Documenting loss of large trophy fish from the Florida Keys with historical photographs. *Conservation Biology* **23**, 636–643.

Moroka P/L (2010) Understanding the environmental water requirements of the Gippsland Lakes systems. Stage 2: Input to the Gippsland Region Sustainable Water Strategy. East and West Gippsland Catchment Management Authorities, Traralgon.

Morris K, Boon PI, Raulings EJ and White SE (2008) Floristic shifts in wetlands: the effects of environmental variables on the interaction between *Phragmites australis* (Common Reed) and *Melaleuca ericifolia* (Swamp Paperbark). *Marine and Freshwater Research* 59, 187–204.

Parks Victoria (1997) Lake Wellington Wetlands Draft Management Plan. Parks Victoria, Kew.

Pickard J (2002) Assessing vegetation change over a century using repeat photography. *Australian Journal of Botany* **50**, 409–414.

Raulings E, Boon PI, Bailey PC, Morris K, Roache MC and Robinson RR (2007) Rehabilitation of Swamp Paperbark (*Melaleuca ericifolia*) wetlands in south-eastern Australia: effects of hydrology, microtopography, plant age and planting technique on the success of community-based revegetation trials. *Wetland Ecology and Management* **15**, 175–188.

Raulings E, Morris, K, Roache M and Boon PI (2010) The importance of water regimes operating at small spatial scales for the diversity and structure of wetland vegetation.

Freshwater Biology **55**, 701–715.

Raulings E, Morris, K, Roache M and Boon PI (2011) Is hydrological manipulation an effective management tool for rehabilitating chronically flooded, brackish-water wetlands? *Freshwater Biology* **56**, 2347–2369.

Robertson M, Nichols P, Horwitz P, Bradby K and MacKintosh D (2000) Environmental narratives and the need for multiple perspectives to restore degraded landscapes in Australia. *Ecological Health* **6**, 119–133.

Robinson RR, Boon PI and Bailey PC (2006) Germination characteristics of *Melaleuca ericifolia* Sm. (Swamp Paperbark) and their implications for the rehabilitation of coastal wetlands. *Marine and Freshwater Research* **57**, 1–9.

Robinson RW, James EA and Boon PI (2012) Population structure in the woody wetland plant *Melaleuca ericifolia* Sm. (Myrtaceae): an analysis using historical aerial photographs and molecular techniques. *Australian Journal of Botany* **60**, 9–19.

Salt T, Langton S and Doyle M (2008) The challenges of restoring the Everglades ecosystem. In *Large-scale Ecosystem Restoration*, pp. 5–33. Ed M Doyle and CA Drew. (Island Press: Washington)

Salter J, Morris K, Bailey PCB and Boon PI (2007) Interactive effects of salinity and water depth on the growth of seedling Swamp Paperbark (*Melaleuca ericifolia* Sm). *Aquatic Botany* **86**, 213–222.

Salter J, Morris K and Boon PI (2008) Does salinity reduce the tolerance of two contrasting wetland plants, the submerged monocot *Vallisneria australis* and the woody shrub *Melaleuca ericifolia*, to wetting and drying? *Marine and Freshwater Research* **59**, 291–303.

Salter J, Morris K, Read J and Boon PI (2010a) Impact of long-term, saline flooding on condition and reproduction of the clonal wetland tree, *Melaleuca ericifolia* (Myrtaceae). *Plant Ecology* **206**, 41–57.

Salter J, Morris K, Read J and Boon PI (2010b) Understanding the potential effects of water regime and salinity on recruitment of *Melaleuca ericifolia* S. *Aquatic Botany* **92**, 200–206.

Saunders KM, Hidgson DA, Harrison J and McMinn A (2008) Palaeological tools for improving the management of coastal ecosystems: a case study from Lake King (Gippsland Lakes) Australia. *Journal of Paleolimnology* **40**, 33–47.

Scott A (1998) The ecology of the Tuggerah Lakes: an oral history. CSIRO Land and Water: Technical Report 40/98, Canberra.

Sinclair S and Boon PI (2012) Changes in the area of coastal marsh in Victoria since the mid 19th century. *Cunninghamia* **12**, 153–176.

Sinclair Knight Merz (2003) Dowd Morass Salt and Water Balance and the Impact of Management Options. Department of Sustainability and Environment and Parks Victoria, Maffra.

State Rivers and Water Supply Commission (1972) Dowd's Morass. Report on Hydrological and Legal Aspects with Particular Reference to Proposed Extension of Reserve for Preservation of Wildfowl. State Rivers and Water Supply Commission, Melbourne.

Toomey M and Boon PI (2007) Response of Brazilian Milfoil (*Myriophyllum aquaticum*) to salinity and water-level fluctuations and its potential to invade wetlands of the Gippsland Lakes, south-east Victoria. *Proceedings of the 3rd Victoria Weed Conference* 3–4 October 2007, Bendigo.

URS (2008) The Gippsland Lakes EWR study – socio-economic attributes. East and West Gippsland Catchment Management Authorities, Traralgon.

Walters C (1986) *Adaptive Management of Renewable Resources*. (Macmillan: New York)

Watson D (1984) *Caledonia Australis. Scottish Highlanders on the Frontier of Australia.* (Vintage: Sydney)

Weiher E (2007) On the status of restoration science: obstacles and opportunities. *Restoration Ecology* **15**, 340–343.

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One Hundred Years Ago

PAPER READ

By Dr. T. S. Hall, M.A., D.Sc, entitled "Notes on the Gippsland Lakes."

The author, in the course of an interesting paper, illustrated by lantern slides, traced the extent of the Gippsland Lakes, which were formerly estuaries of rivers, but had become lakes by the action of sand-dunes, which still continue to form along their seaward margins. The position of portion of- the old coast-line was still marked by cliffs of marine Tertiaries in several places. He said that it seemed probable that the altered conditions which now exist could be traced to the breaking-down of the land-bridge which once existed between Australia and Tasmania and the probable change in the ocean currents which followed the formation of Bass Strait. The chairman said the thanks of the Club were due to the author for his very interesting and instructive paper.

Messrs. A. D. Hardy, G. A. Keartland, and A. H. E. Mattingley took part in a short discussion which followed.

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